NASA and Cryogenic Technology Applications

Liquid Hydrogen Technologies Workshop

hosted by

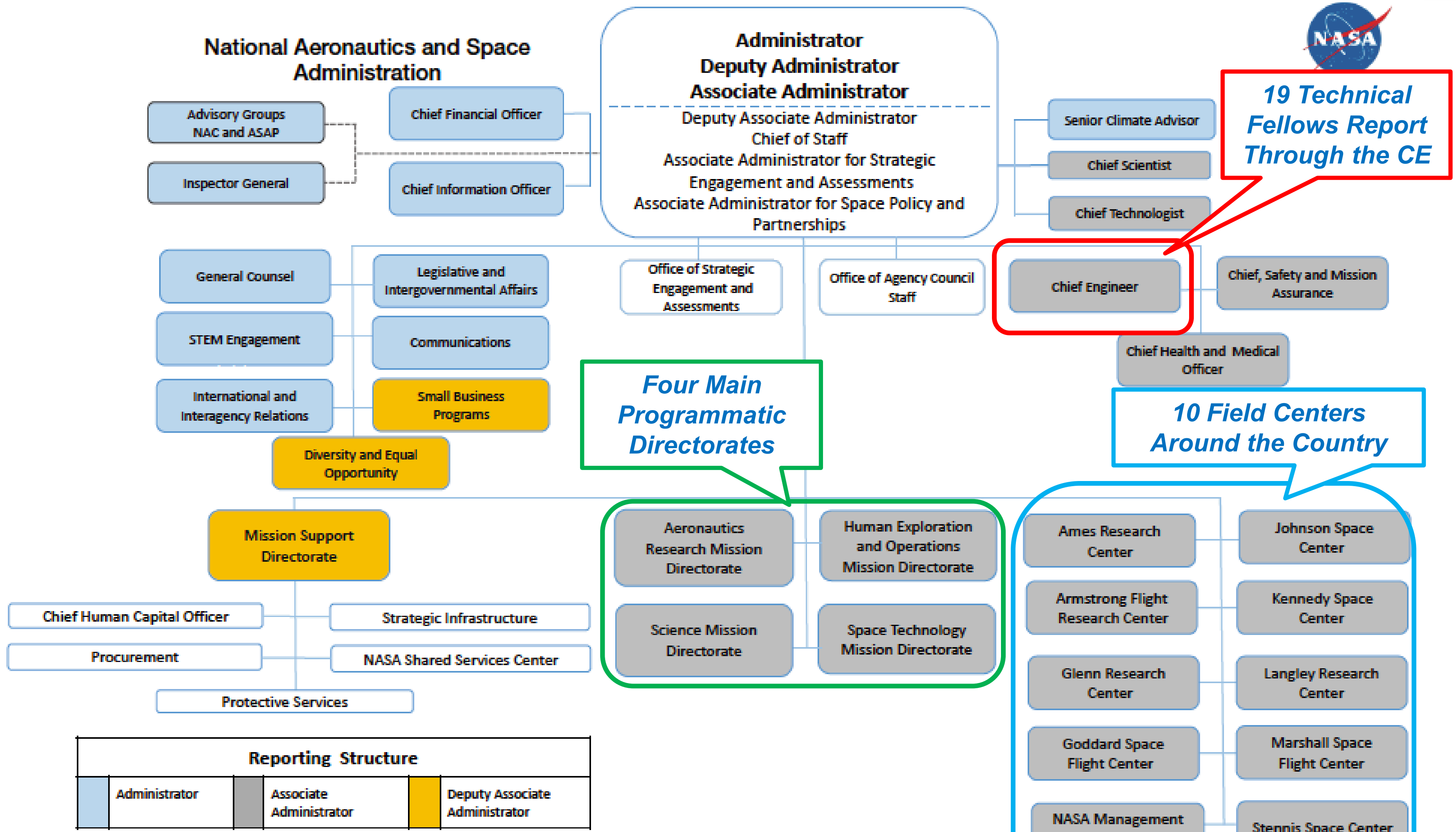
The U.S. Department of Energy's Hydrogen and Fuel Cell Technologies Office and
the National Aeronautics and Space Administration's Cryogenic Technical Discipline Team

February 22-23, 2022

Michael L. Meyer

NASA Technical Fellow for Cryogenics
NASA Engineering and Safety Center
NASA Langley Research Center

NASA Organizational Structure



Note: Administrator may delegate direct reports to Deputy Administrator at his/her discretion.
* NMO oversees the Jet Propulsion Laboratory contract.
** Programmatic reporting to the Science Mission Directorate Associate Administrator.
JPL will participate in Agency-level functions, such as APMC.
JPL is a Federally Funded Research and Development Center (FFRDC).

www.nasa.gov February 2021

Decomposition of Cryogenics at NASA
- Scope of the Cryogenics Technical Discipline Team (TDT)

Thermal conditioning for Sensors, Instruments, and High Efficiency Electronic Motors

- Thermal parasitics
- Refrigeration below 10K
- Refrigeration above 10K
- Solid cryogens heat sink
- Solar Shields
- Coatings
- Heat switches

In-space Propellant Storage & Utilization

- Vacuum/partial vacuum insulation
- Micro-g fluid dynamics
- PMDs
- Gauging
- Pressure control
- CFD
- Cryocooling/zero boil-off
- Propellant Transfer
- Liquefaction

Launch Vehicle Propellant

- Atmospheric tank/line insulation
- Stratification
- Slosh/ullage collapse
- Feedline chill
- Geysering
- Mass Gauging
- Quick Disconnects

Ground Testing and Operations

- Atmospheric Insulation
- Densification
- Large Scale Refrigeration
- Quick Disconnects
- Cryogenic Pumps
- Leak/Fire Detection
- Automation/Fault Detection

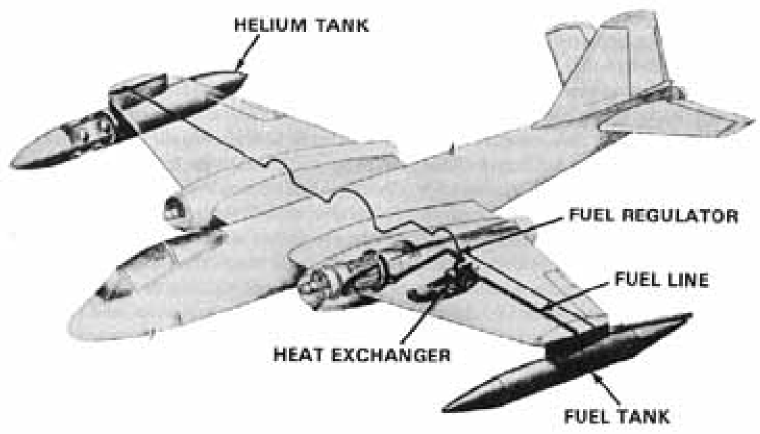
Continued expertise in *Cryogenic Analysis, Safety, & Properties are* ***key to success in all areas of the discipline***

“Aeronautics” Flew with Liquid Hydrogen Before NASA Was Created

Then

NACA Lewis (now Glenn) conducts Project Bee (1955-1959)

- B-57B modified to permit one engine to burn JP-4 or H_2



Now

The Center for High-Efficiency Electrical Technologies for Aircraft (CHEETA)

- A multi-disciplinary consortium of researchers, scientists, and engineers from a variety of universities, laboratories, and industry groups.
- Studying electric aviation including superconductive components cooled by LH2 with H2 fuel cell generated electricity.

CHEETA
Center for High-Efficiency Electrical Technologies for Aircraft

Launch Systems and Ground Testing Systems

Space Launch System

- Thrust = 8.8-11.9 Mlbs
- Total On-Board Cryo Prop.
- **LO_2 = 995 m^3, LH_2 = 1,770 m^3**
- First Launch: Spring 2022

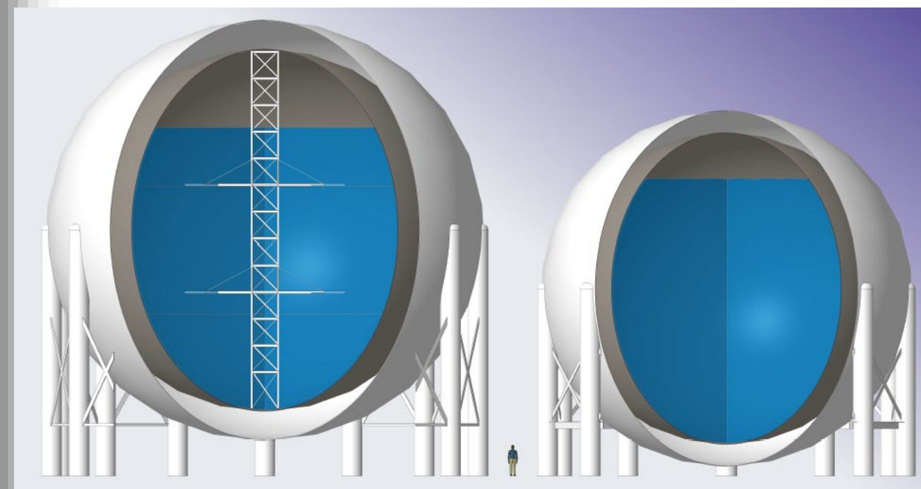
98 m

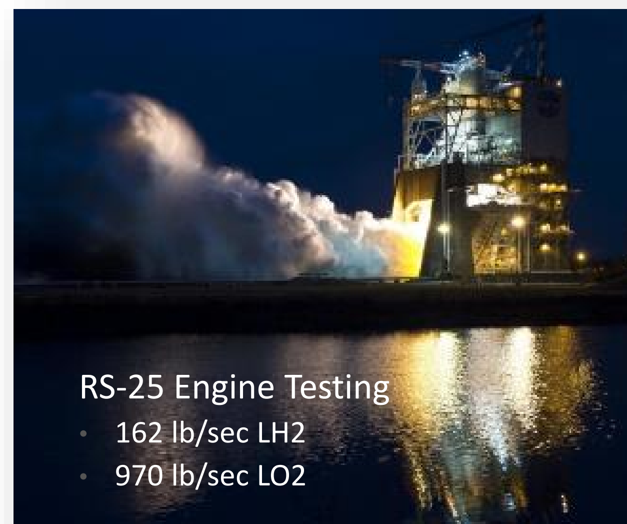
New LH2 Sphere

- 4,733 m^3
- Glass bubble insulation
- Integrated refrigeration HX

Apollo LH2 Sphere

- 3400 m^3

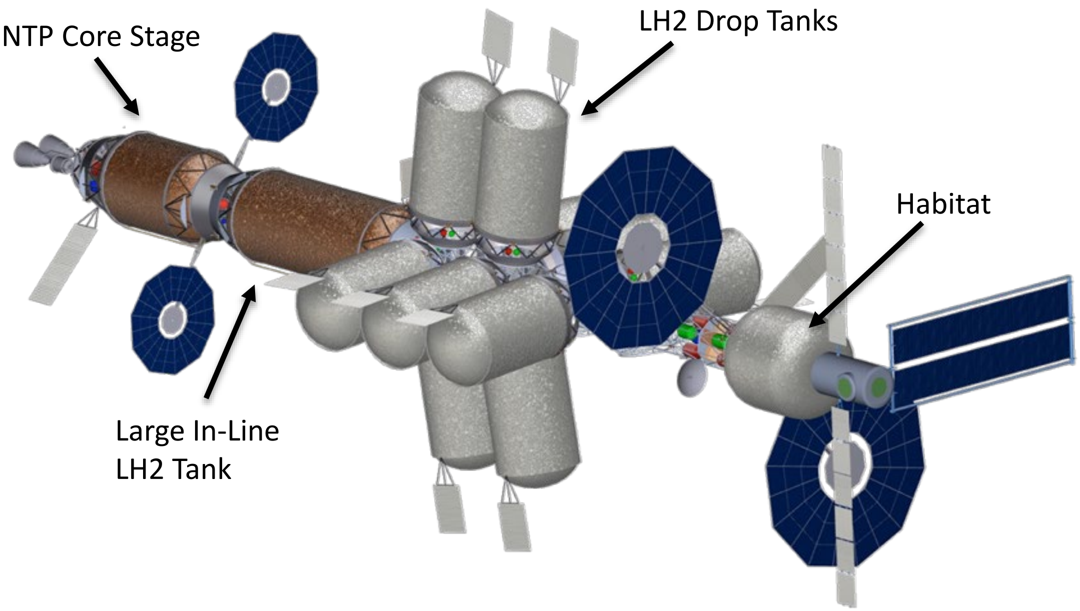




What Might a Crewed Mars Mission Look Like?

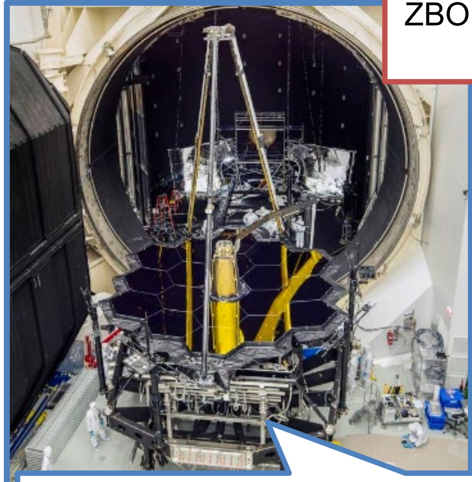
The orbital mechanics generally require a 2 – 3 year round trip and requires a very large amount of propulsive energy

- One concept uses a Nuclear Thermal Propulsion (NTP)
    - Reactor, LH2 pump, hydrogen heat exchange, and a converging expanding nozzle to generate thrust
- Liquid hydrogen storage in multiple large tanks (high performance passive thermal control with integrated refrigeration for zero LH2 loss)
- Large habitat for crew
- In-space assembly



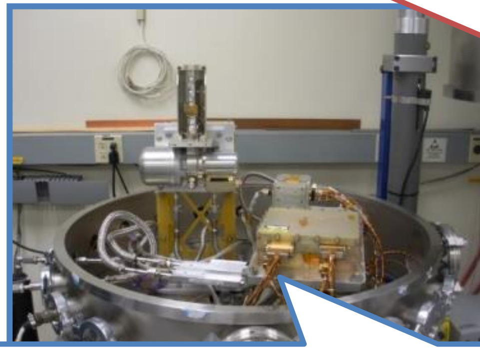
Strategic/Key Facilities and Assets

Key cryogenic facilities encompass a wide range of sizes, types, and capabilities

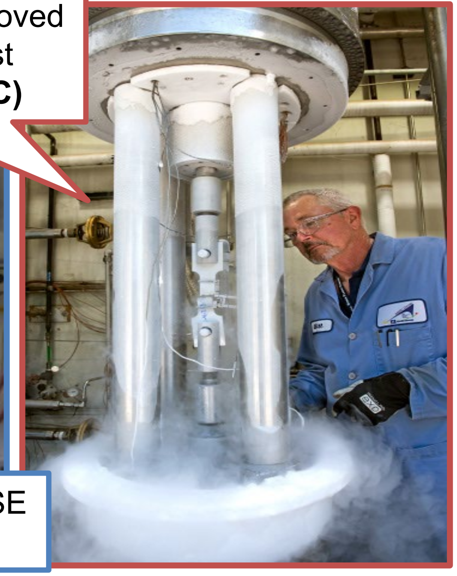


JWST emerging from Chamber A **(JSC)**

ZBO Test Article at the Small Multi-Purpose Research Facility (SMiRF) **(GRC)**



NGAS HEC Cryocooler in the CSE 3-ft Vacuum Chamber **(JPL)**



Test Sample being removed at the Hydrogen Test Facility (HTF) **(MSFC)**

Cryogenics Test Lab **(KSC)**

ISCPPD Cryogenic Component Test Facility **(ARC)**

240,000 Gallon Liquid Hydrogen Supply Barges **(SSC)**

Cryogenic Research and Integration Facility (CRIF) **(GSFC)**